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Method and device for detecting an object in a motor vehicle environment

The invention relates to a method and a device for detecting an object in a motor vehicle environment using a detection means scanning the environment at predetermined angular increments.

DE 101 16 277 A1 has disclosed a device for detecting objects during driven operation of a motor vehicle using a scanning detection means, in particular a laser, objects moving in relation to the vehicle being classified as regards object size, degree of reflection, speed and acceleration. Using a subcombination of these evaluation variables, an assigning identification of the object is carried out, for example as a passenger vehicle, an HGV, a motorcycle, a bicycle or a pedestrian.

In addition, DE 195 03 960 A1 describes an object detection device for vehicles having a laser for the purpose of emitting light and a light-receiving device for the purpose of receiving the light reflected by an object (laser scanner). The pulsed laser scans an environment using a predetermined number of increments, for example using a number of 100 increments, the distance and the speed of the object being determined in computing devices.

An obstacle identification device identifies the detected object on the basis of a distribution pattern of the light intensity received.

The applicant considers a disadvantageous factor in the known radar devices to be the fact that the resolution of the laser scanners used is in many applications

insufficient in the operating mode to be able to reliably determine the extent of an object to be detected.

The invention is now based on the object of specifying an improved method for detecting an object in a motor vehicle environment using a detection means scanning the environment at predetermined angular increments. In addition, a device is specified for carrying out the method.

The first-mentioned object is achieved by a method for detecting an object in a motor vehicle environment having the features of patent claim 1.

According to the invention, when sensing a reflection signal of an object at an angle φi $(i=1,2,...,N)$, the angular increments are refined in the angular range between the adjacent angles $\varphi i-1$ and $\varphi i+1$ as a function of the signal propagation times $ti-1$, ti and $ti+1$ of the reflection signals sensed at the angles $\varphi i-1$, φi and $\varphi i+1$. In order to detect the object in a motor vehicle environment, a detection means is used which scans the environment at predetermined angular increments $\varphi i+1-\varphi i$. With many assisting and safety functions in the vehicle it is impossible to dispense with knowledge of the precise dimensions of the objects located in the environment. The method ensures very accurate determination of the dimensions of an object, for example of a road user, as a result of which, for example, it is possible for it to be reliably assigned to classes such as a pedestrian, two-wheeler, passenger car and HGV. Each of these classes is characterized by a specific acceleration behavior and movement pattern in the road traffic. A targeted and safe response to a current traffic situation is made possible by the method.

In one refinement, at least one angle φz (z=1,2,...,N) additionally to be sensed is introduced in the angular range between the angles $\varphi i-1$ and φi or φi and $\varphi i+1$ if the absolute propagation time difference between the signal propagation times ti and ti-1 or ti and ti+1 of the reflection signals exceeds a predetermined threshold value. The predetermined threshold value for the absolute propagation time difference is selected such that distinctive object features (for example lamps or a radiator grille in a vehicle) lead to measurable propagation time differences between adjacent reflection signals which lie below the predetermined threshold value for the absolute propagation time difference. Absolute propagation time differences between the signal propagation times ti and ti-1 or ti and ti+1 of adjacent reflection signals above the predetermined threshold value are a clear indication of obvious geometrical changes which can be associated, in particular, with object boundaries (for example the front, right-hand corner of the vehicle). The introduction of an angle φz additionally to be sensed in the angular range between the angles $\varphi i-1$ and φi or φi and $\varphi i+1$ makes it possible for object boundaries to be determined substantially more accurately. The method, namely the introduction of further angles φiz additionally to be sensed, is continued until reliable detection of the size and classification of the object is ensured.

It is advantageous if the scanning takes place substantially horizontally, vertically and/or at a predetermined angle of inclination. With scanning which is carried out vertically or at a predetermined angle of inclination, the presence and the position of a curb can be detected. This prevents the vehicle from driving onto the curb or ensures that it does so in a manner which is not damaging to the tires. The position and alignment of the curb can also be used for the

selection of a desired vehicle position in a parking space. In addition, the knowledge of the position of a curb can be used for finding vacant parking spaces which are not provided or delimited by two vehicles but lie in front of, behind or next to a single vehicle and are delimited on the other side by a curb.

The second-mentioned object is achieved by a device for detecting an object in a motor vehicle environment having the features of patent claim 9.

According to the invention, the angles φi to be scanned can be set individually using the device. As a result, a cost-effective sensor system is provided for the purpose of detecting an object in a motor vehicle environment using one or a very limited number of measuring beams, which system is compact and can be positioned in many locations in the vehicle owing to its low installation depth.

The invention will be explained in more detail with reference to an exemplary embodiment in the single figure, the figure showing a schematic illustration of a plan view of a section of an object in a motor vehicle environment.

An object 1 illustrated in section in the figure is located in the environment of a motor vehicle which is not illustrated in any more detail and has detection means scanning the environment at predetermined angular increments for the purpose of detecting the object 1. The number of angular increments depends on the required resolution accuracy. The object 1 has a corner 4 and a bulge 5 in a surface profile 2. If the object 1 is a motor vehicle, the corner 4 could be, for example, a front, lateral boundary and the bulge 5 may be a headlamp. The object 1 may be a moving road user or road traffic devices having a fixed position. Moving

road users are, for example, pedestrians, two-wheelers, passenger cars and HGVs. Devices having a fixed position are, in particular, street signs and road markings, for example curbs.

The scanning detection means comprises a sensor indicating the distance, it being possible for the angles φi (i=1,2,3...N) to be scanned to be set individually, and the spatially delimited measuring direction of the sensor being indicated by an arrow 3. The scanning takes place substantially horizontally in this application, i.e. parallel to a road surface. In order to improve understanding of the exemplary embodiment, the emitted beam from the sensor associated with the reflection signal 6 to 13 is illustrated in the figure as the reflection signal 6 to 13. For further simplification purposes, the reflection signals 6 to 13 which are detected at the angles φ6, φ7 to φ13 by scanning detection means are illustrated as parallel beams.

The reflection signals 7, 8, 9, 11 are reflected by a planar face 14, which faces the vehicle, of the surface profile 2 of the object 1. The planar face 14 of the object 1 takes up the majority of the view of the object 1 which faces the motor vehicle and can be detected by the laser of the motor vehicle.

In a method for detecting the object 1 in the motor vehicle environment, when sensing reflection signals 6 to 11 at the respective angles φ6 to φ11, the angular increments are refined in the angular range between adjacent angles φ6 to φ11 as a function of the signal propagation times t6 to t11 of the sensed reflection signals 6 to 11. If the absolute propagation time difference between the signal propagation times t6 to t11 of two respectively adjacent reflection signals 6 to 11 exceeds a predetermined threshold value, at least

one angle $\varphi 12$ additionally to be sensed is introduced in the angular range between these respectively adjacent reflection signals 6 to 11.

A threshold value of the path difference for the reflection signals 6 to 13 corresponds to the predetermined threshold value for the absolute propagation time difference since the reflection signals 6 to 13 in each case propagate at the speed of light. The path difference is shown in the figure as the path difference window 15 in relation to the reflection signals 7, 8, 9 and 11. For a simplified illustration, the path difference window 15, which is of equal size for all of the reflection signals 6 to 13, has not been shown in the figure for the reflection signals 6, 10, 12 and 13. The threshold value of the absolute propagation time difference and, correspondingly, the path difference window 15 is selected to be so large that, in the event of a deviation in the path difference between two adjacent reflection signals 6 to 13 which is greater than the path difference window 15, it can be assumed that the two reflection signals do not belong to the object 1.

The method will be described in detail below. In a first scanning run of the object 1 with the reflection signals 6 to 11, for example with scanning at constant angular increments, the object 1 is detected with the reflection signals 7 to 11. The reflection signals 7 to 11 are reflected by the object 1 and detected by the scanning detection means of the motor vehicle, while the reflection signal 6 is not incident on the object 1 and passes to the side of it. With the first scanning run, the dimensions, in the case of horizontal scanning the width, of the object 1 are generally not detected accurately enough in order to be able to uniquely classify the object 1. A specific driving behavior of the motor vehicle as a response to the presence of the

object 1 can generally not be estimated or derived from the results of the first scanning.

In order to detect the width of the object 1 more accurately, the signal propagation times t6 to t11 of the reflection signals 6 to 11 are evaluated for a second scanning run of the object 1. For each pair of directly adjacent reflection signals 6 to 11, the absolute propagation time difference of their signal propagation times t6 to t11 is calculated and compared with the predetermined threshold value for the absolute propagation time difference. The absolute propagation time difference of directly adjacent reflection signals 6 to 11 may be greater or less than the predetermined threshold value for the absolute propagation time difference. Correspondingly, it is true for the path difference of two directly adjacent reflection signals 6 to 11 that this path difference lies within the corresponding path difference window 15 for an absolute propagation time difference less than the predetermined threshold value. The adjacent reflection signals 6 and 7 have an absolute propagation time difference which is greater than the predetermined threshold value for the absolute propagation time difference. All other reflection signals 8 to 11 have an absolute propagation time difference in relation to their respectively adjacent reflection signals 7 to 11 which is less than the prescribed threshold value for the absolute propagation time difference. Owing to the suitable selection of the threshold value for the absolute propagation time difference, the bulge 5 is also recognized as being associated with the object 1.

For accurate determination of the lateral boundary of the object 1 in the region of the corner 4 during the second scanning run, at least one further reflection signal 12 (illustrated for distinguishing purposes as a dashed arrow) is generated at an angle φ12 in the

angular range between the angles $\varphi6$ and $\varphi7$, at which the reflection signals 6 and 7 are received. The angular range between the angles $\varphi6$ and $\varphi7$ is as a result scanned during the second scanning run with a higher resolution than during the first scanning run in order to determine more accurately the boundary of the object 1. However, two or more angles to be sensed can additionally be introduced into the angular range for the second scanning run. The angle $\varphi12$ additionally to be sensed can be determined in an interval nesting method, for example by halving the angular range between the angles $\varphi6$ and $\varphi7$, or in an iteration method with a suitable weighting. The reflection signal 12 is likewise reflected by the object 1 and defines the boundary of the object 1 markedly better than the reflection signal 7.

If the desired resolution for the width of the object 1 is still insufficient after the second scanning run, the method is continued. For each pair of directly adjacent reflection signals 6 to 12, in turn the absolute propagation time difference of their signal propagation times t6 to t12 is calculated and compared with the predetermined threshold value for the absolute propagation time difference. The reflection signals 6 and 12 have an absolute propagation time difference which is greater than the predetermined threshold value for the absolute propagation time difference. In a further scanning run, a reflection signal 13 (illustrated for distinguishing purposes as a dotted arrow) is therefore generated at an angle $\varphi13$ in the angular range between the reflection signals 6 and 12. The reflection signal 13 is not reflected by the object 1. The method for detecting the object 1 in the motor vehicle environment can be continued until reliable detection of the object 1 is ensured by sufficiently accurate determination of the dimensions.

The scanning is carried out horizontally in this exemplary embodiment. However, it may also be carried out vertically or at a predetermined angle of inclination. With vertical scanning, in addition to the height of the object 1, the presence and the height of curbs as the road boundary can also be detected. Curbs have two sharp edges (in each case one edge at the level of the road and at the level of the sidewalk) and a curb wall perpendicular to the road surface. As a result, curbs can be detected very effectively using the method according to the invention both in terms of their position and in terms of their height.